

Date of Deposit: September 15, 2000

## 4-KBITS/S SPEECH CODING

### INVENTORS

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### BACKGROUND OF THE INVENTION

#### 1. Cross Reference to Related Applications.

This application claims the benefit under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Serial No. 60/155,321 entitled "4-KBITS/S SPEECH CODING," (Attorney Docket No. 99RSS485P), filed September 22, 1999; and is a continuation-in-part of United States Patent Application Serial Number 09/574,396 (Attorney Docket No. 246/258), "A NEW SPEECH GAIN QUANTIZATION STRATEGY," filed May 19, 2000, and is now United States Patent Number 6,782,560, both of which are incorporated by reference in their entirety.

The following commonly assigned U.S. patents and co-pending and commonly assigned U.S. patent applications further describe other aspects of the embodiments disclosed in this application and are incorporated by reference in their entirety.

United States Patent Number 5,689,615, "USAGE OF VOICE ACTIVITY DETECTION FOR EFFICIENT CODING OF SPEECH," issued November 18, 1997.

United States Patent Number 5,774,839, "DELAYED DECISION SWITCHED PREDICTION MULTI-STATE LSF VECTOR QUANTIZATION," issued June 30,

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1998.

United States Patent Number Patent Number 6,104,992, "ADAPTIVE GAIN REDUCTION TO PRODUCE FIXED CODEBOOK TARGET SIGNAL," issued August 15, 2000.

United States Patent Application Serial Number 09/156,649 (Attorney Docket No. 95E020), "COMB CODEBOOK STRUCTURE," filed September 18, 1998, and is now United States Patent Number 6330531.

United States Patent Application Serial Number 09/365,444 (Attorney Docket No. 97RSS380), "BI-DIRECTIONAL PITCH ENHANCEMENT IN SPEECH CODING SYSTEMS," filed August 2, 1999, and is now United States Patent Number 6704701.

United States Patent Application Serial Number 09/156,814 (Attorney Docket No. 98RSS365), "COMPLETED FIXED CODEBOOK FOR SPEECH ENCODER," filed September 18, 1998, and is now United States Patent Number 673257.

United States Patent Application Serial Number 09/761033 "SYSTEM FOR AN ADAPTIVE EXCITATION PATTERN FOR SPEECH CODING," Attorney-  
~~Reference Number: 98RSS366 (10508.9), filed on September 15, 2000, and is now~~  
~~United States Patent Number~~

~~United States Patent Application Serial Number 09/574,396 (Attorney Docket No. 99RSS312), "COMPLETED FIXED CODEBOOK FOR SPEECH ENCODER," filed May 19, 2000, and is now United States Patent Number 678266.~~

United States Patent Application Serial Number 09/154,660 (Attorney Docket No. ~~98RSS384~~), "SPEECH ENCODER ADAPTIVELY PITCH PREPROCESSING WITH CONTINUOUS WARPING," filed September 18, 1998, and is now United States Patent Number 6330533.

United States Patent Application Serial Number 09/154,662 (Attorney Docket No. ~~98RSS383~~), "SPEECH CLASSIFICATION AND PARAMETER WEIGHTING USED IN CODEBOOK SEARCH," filed September 18, 1998, and is now United States Patent Number 6493665.

United States Patent Application Serial Number 09/154,675 (Attorney Docket No. 97RSS383), "SPEECH ENCODER USING CONTINUOUS WARPING IN LONG TERM PREPROCESSING," filed September 18, 1998, and is now United States Patent Number 6,449,590.

5 United States Patent Application Serial Number 09/154,654 (Attorney Docket No. 98RSS344), "PITCH DETERMINATION USING SPEECH CLASSIFICATION AND PRIOR PITCH ESTIMATION," filed September 18, 1998, and is now United States Patent Number 6,507,814.

10 United States Patent Application Serial Number 09/156,650 (Attorney Docket No. 98RSS343), "SPEECH ENCODER USING GAIN NORMALIZATION THAT COMBINES OPEN AND CLOSED LOOP GAINS," filed September 18, 1998, and is now United States Patent Number 6,260,010.

15 United States Patent Application Serial Number 09/154,657 (Attorney Docket No. 98RSS328), "SPEECH ENCODER USING A CLASSIFIER FOR SMOOTHING NOISE CODING," filed September 18, 1998, ~~and is now United States Patent Number~~

United States Patent Application Serial Number 09/164,084 (Attorney Docket No. 99RSS227), "METHOD FOR SPEECH CODING USING SNR," filed August 16, 2000, ~~and is now United States Patent Number~~

20 United States Patent Application Serial Number 09/164,507 (Attorney Docket No. 99RSS219), "METHOD FOR ROBUST CLASSIFICATION IN SPEECH CODING," filed August 21, 2000, ~~and is now United States Patent Number~~

25 United States Patent Application Serial Number 09/156,648 (Attorney Docket No. 98RSS228), "LOW COMPLEXITY RANDOM CODEBOOK STRUCTURE," filed September 18, 1998, and is now United States Patent Number 6,480,822.

United States Patent Application Serial Number 09/156,416 (Attorney Docket No. 98RSS011), "METHOD AND APPARATUS FOR DETECTING VOICE ACTIVITY

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AND SILENCE IN A SPEECH SIGNAL USING PITCH LAG AND PITCH GAIN  
STATISTICS," filed September 18, 1998, and is now United States Patent Number  
6188981.

United States Patent Application Serial Number 09/154,653 (Attorney Docket No.  
5 97RSS383), "SYNCHRONIZED ENCODER-DECODER FRAME CONCEALMENT  
USING SPEECH CODING PARAMETERS," filed September 18, 1998, and is now  
United States Patent Number 6188980.

United States Patent Application Serial Number 09/156,826 (Attorney Docket No.  
98RSS382), "Adaptive Tilt Compensation For Synthesized Speech Residual," filed  
10 September 18, 1998, and is now United States Patent Number 6395573.

2. Field of the Invention.

The present invention relates to speech coding, and more particularly, to speech  
coding systems that operate at a bit rate of 4 kbits/s.

3. Related Art.

15 Speech coding systems may not operate effectively at low bit rates. When a small  
bandwidth is available to encode speech, the perceptual quality of encoded speech  
declines dramatically. Because of the increase use of wireless communication, there is an  
effort to reduce the bandwidth upon which such wireless communication systems  
operate.

20 To efficiently decrease the wireless bandwidth but still retain a toll quality, a  
speech coding system generally performs a strict waveform matching. Waveform  
matching as employed in a low bit rate wireless coding system, such as 4 kbits/s,  
however, may not perceptually or accurately capture the speech information. Therefore,  
there is a need in the art for a system that provides a speech coding system with a high  
25 perceptual quality at a low bit rate.